Armed Forces College of Medicine

AFCM

cerebellum physiology

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INTENDED LEARNING OBJECTIVES (ILO)

By the end of this lecture the student will be able to:

- Identify the functional divisions of cerebellum
- Describe the body representation in the cerebellum
- Recognize the role of the vestibulo-cerebellum and its afferent and efferent connections in voluntary movement control
- Recognize the role of the spino-cerebellum and its afferent and efferent connections in voluntary movement control
- Distinguish the mechanism of servo-compartor function
- Distinguish the mechanism of damping function

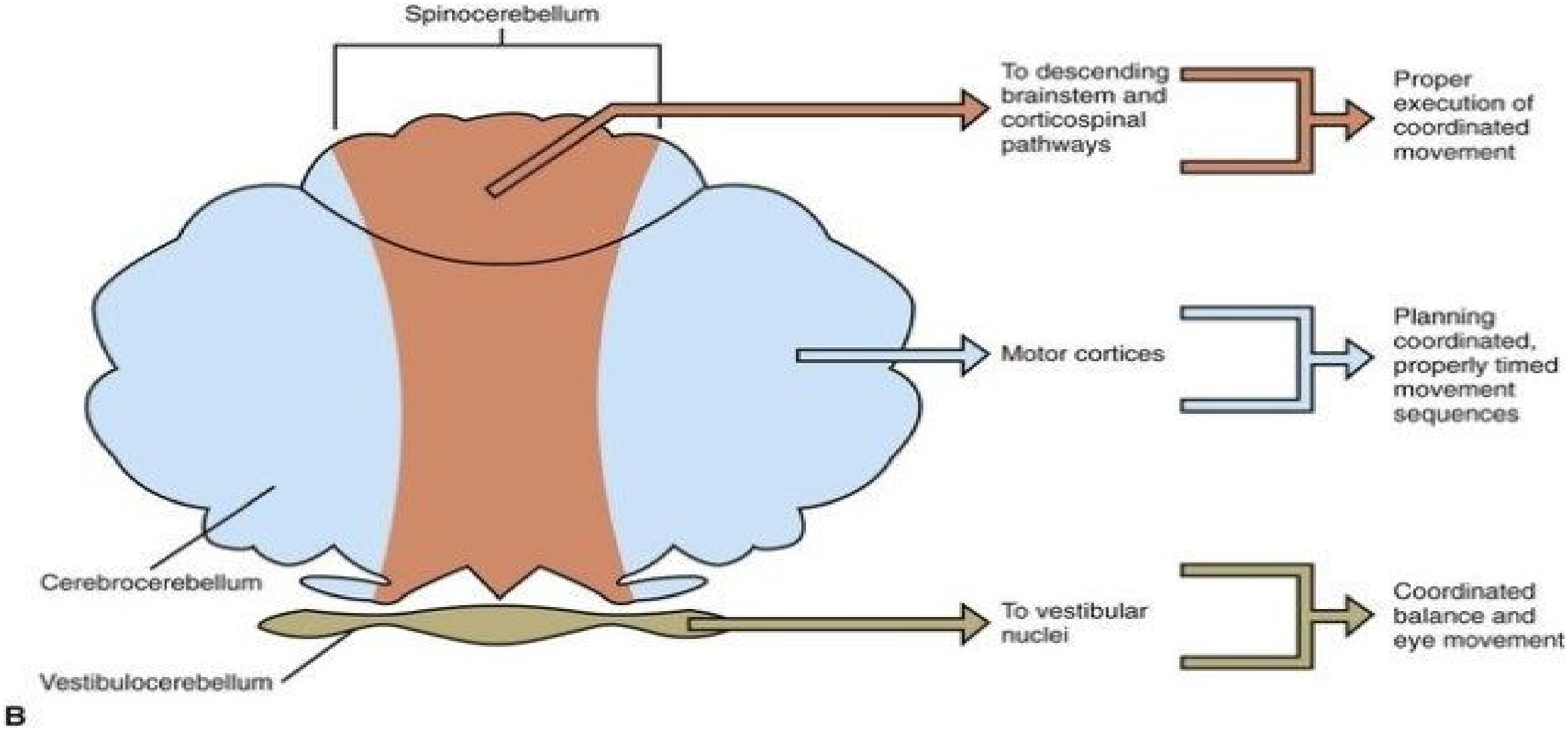
Lecture Plan

- Introduction to cerebellum (5 min)
- Functional divisions of cerebellum (10min)
- Physiological function of each cerebellum division (30 min)
- Summary (5 min)
- Lecture Quiz (5 min)

Cerebellum general functions

- The little brain {Silent brain} only **10 % total volume** of the brain but more than half of all its neurons.
- Receive sensory input but has **no role in sensory awareness**: lesion doesn’t result in sensory loss
- Influence motor behavior **doesn’t initiate movement:** lesion doesn’t cause paralysis
- Cerebellum plays a vital role during **rapid muscular activities** such as running, typing, playing the piano, and talking
- It is formed of 2 cerebellar hemispheres connected by vermis
- Each hemisphere control the same side of the body

Functional divisions of the cerebellum



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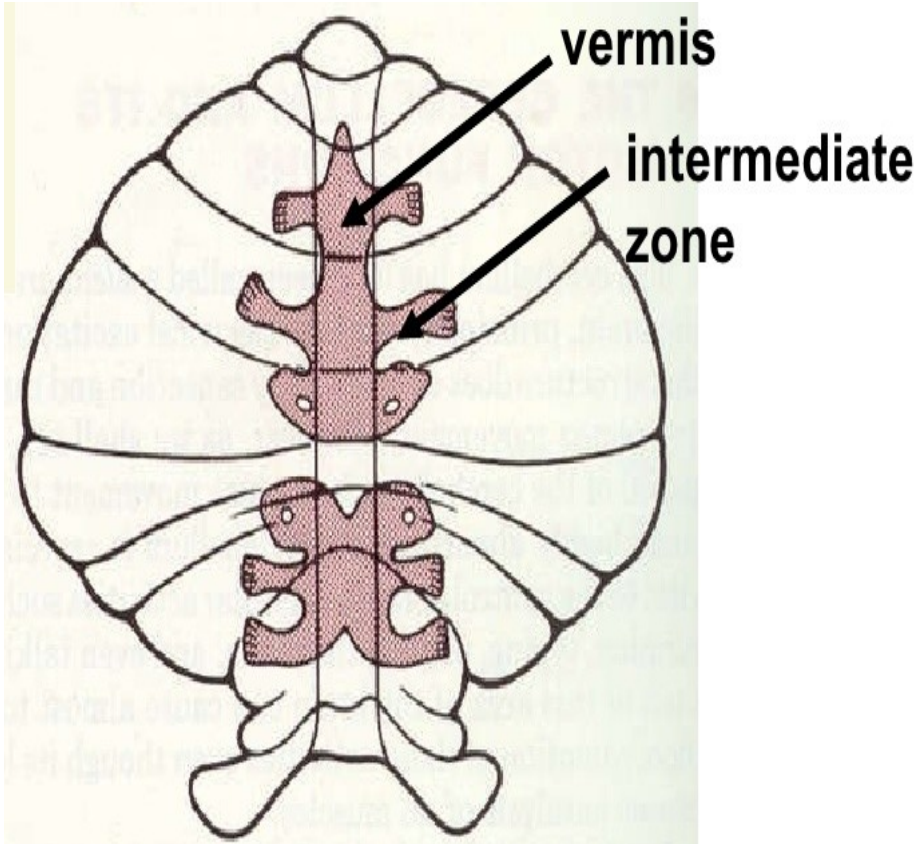
Cerebro-cerebellum {Neo-cerebellum}	**Spino-cerebellum {Paleocerebellum}**	Vestibulo-cerebellum {Archicerebellum}
Lateral parts of cerebellar hemispheres	**Vermis+ intermediate zones of cerebellar hemispheres**	**flocculonodular lobe+ part of vermis**
Planning, programming	**Servo comparator function, Co-ordination of the on-going movement**	**1- maintain equilibrium 2- Control eye movements.**

Topographic representation

- ***2 Maps:***
- *posterior lobe:* upright
- *Anterior lobe:* upside down

- Axial parts in vermis
- Limbs, face in intermediate zones



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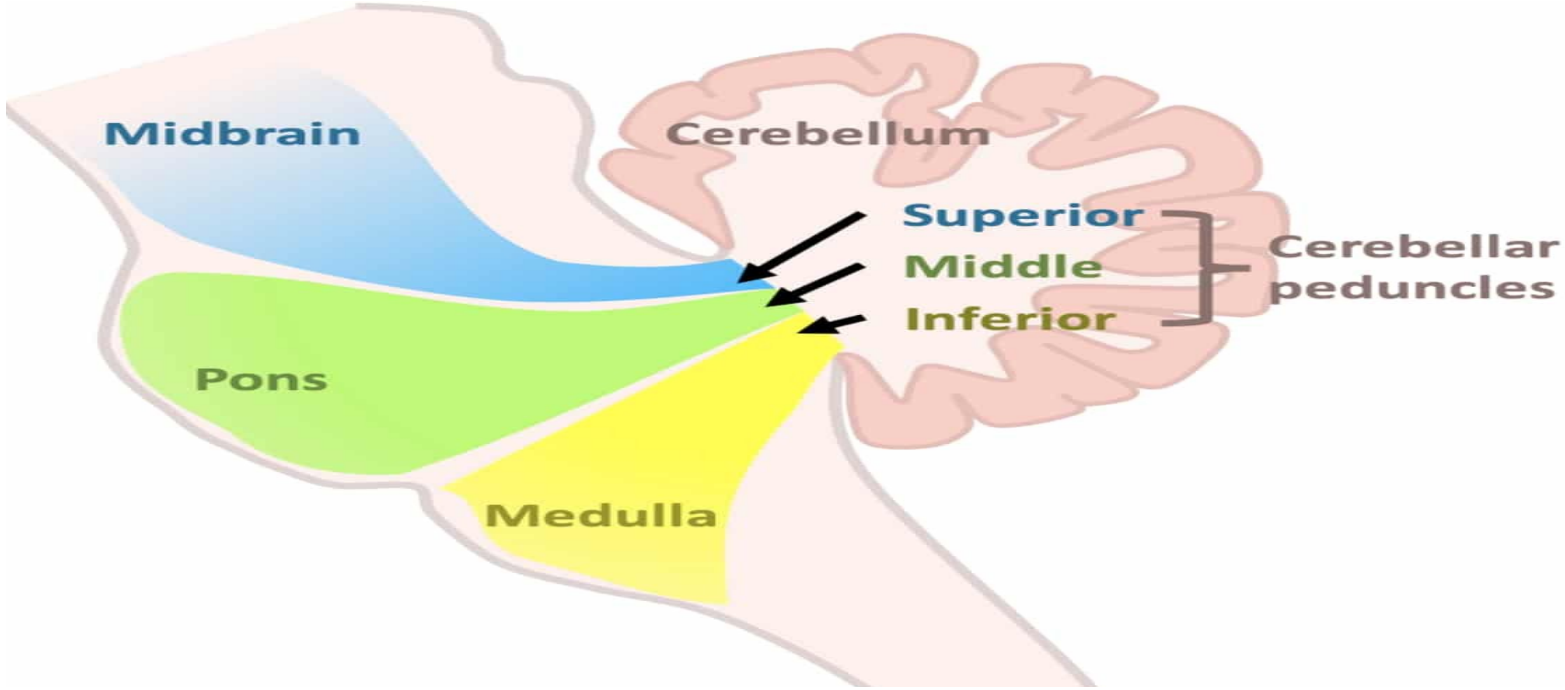
Cerebellum peduncles

- Cerebellum is connected to other brain areas through **3 cerebellar peduncles: superior, middle, inferior**



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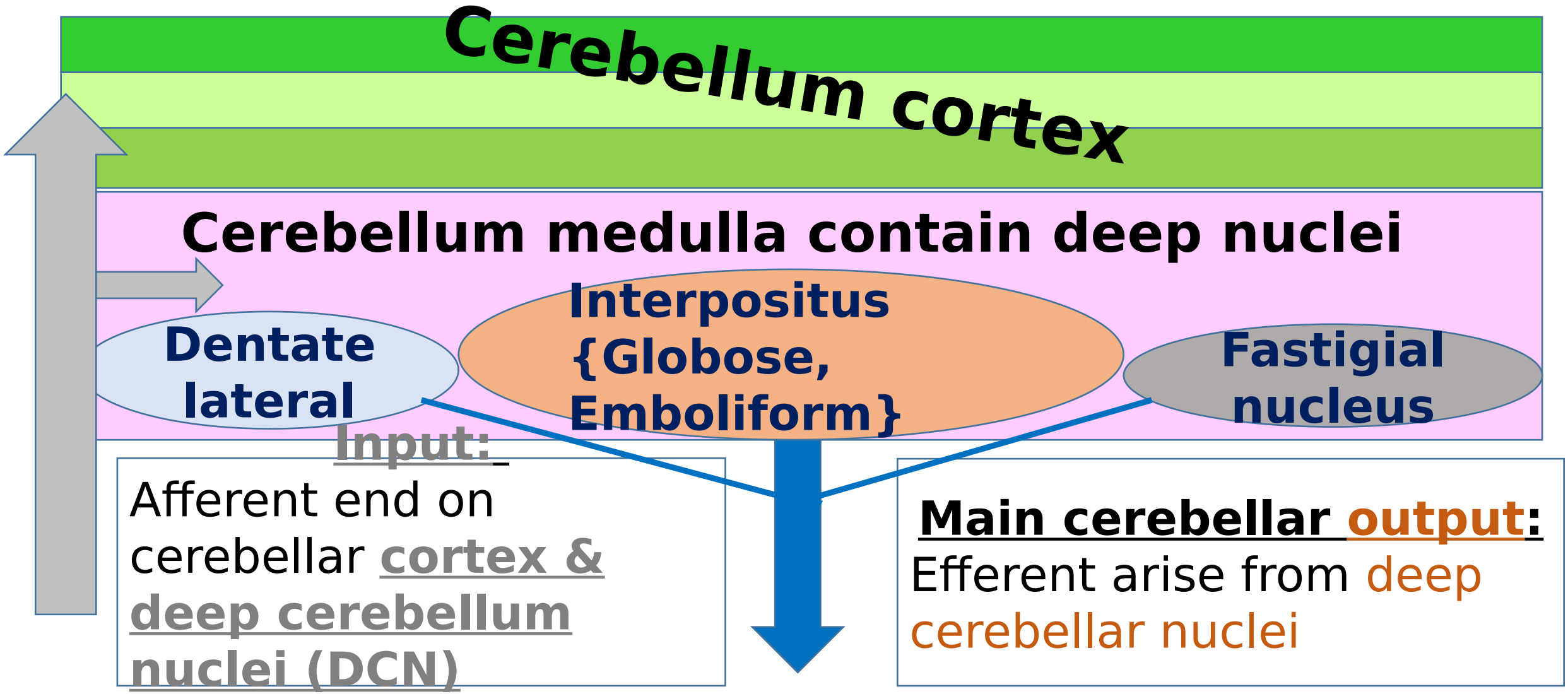
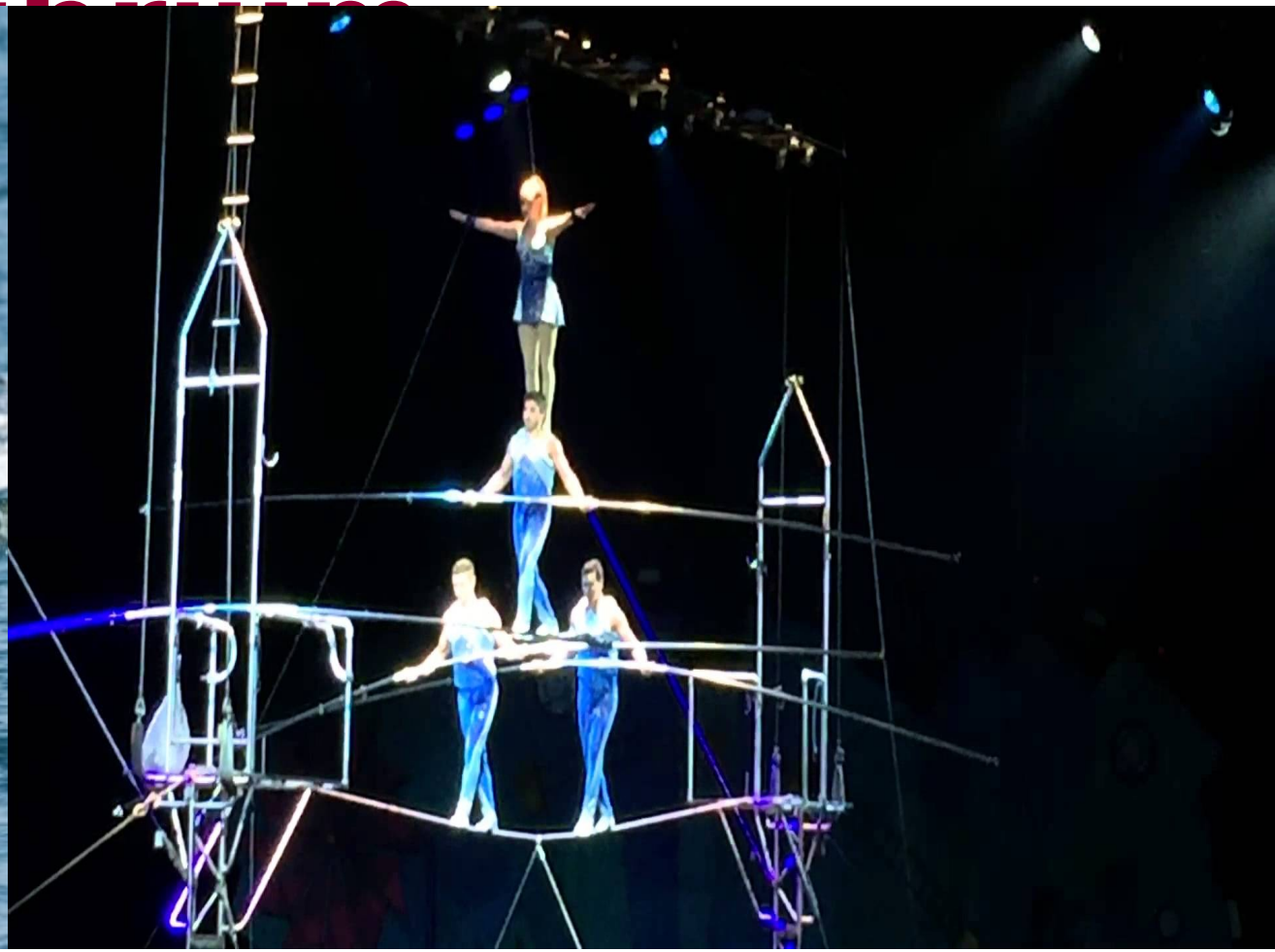
Cerebellum connections



Regulation of body posture, equilibrium

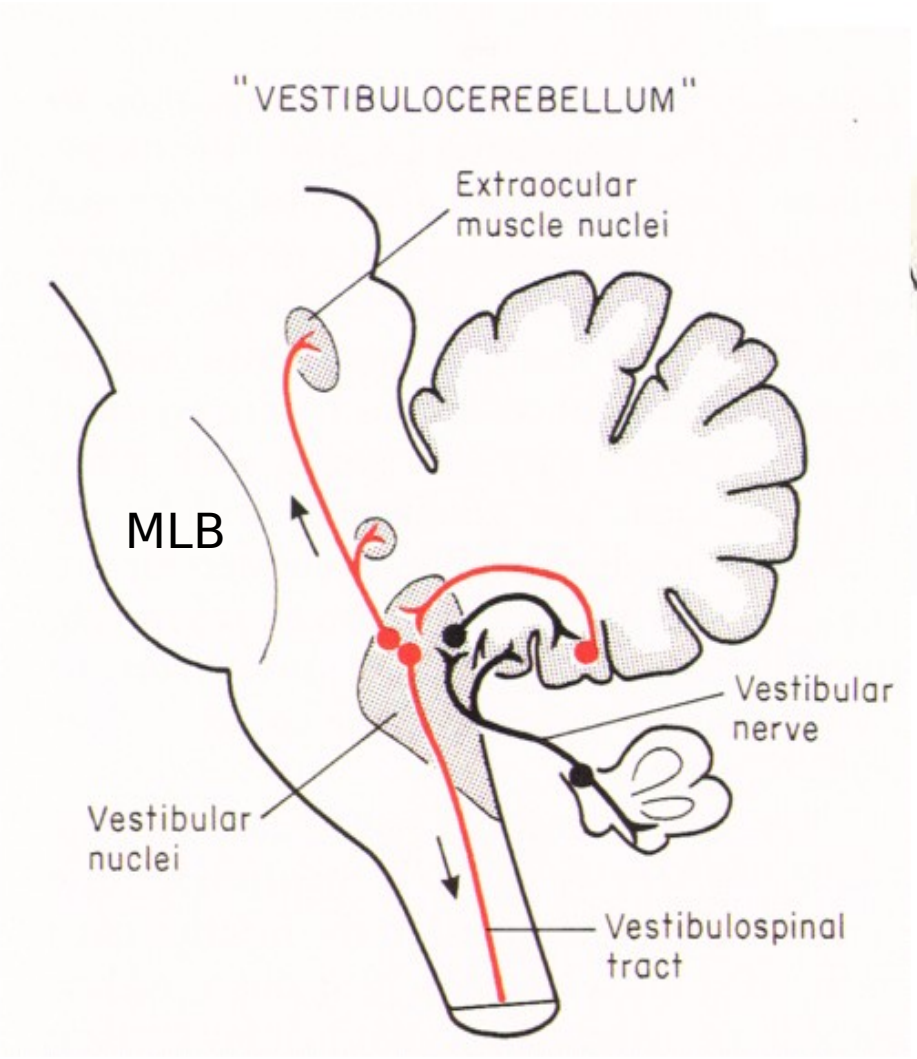


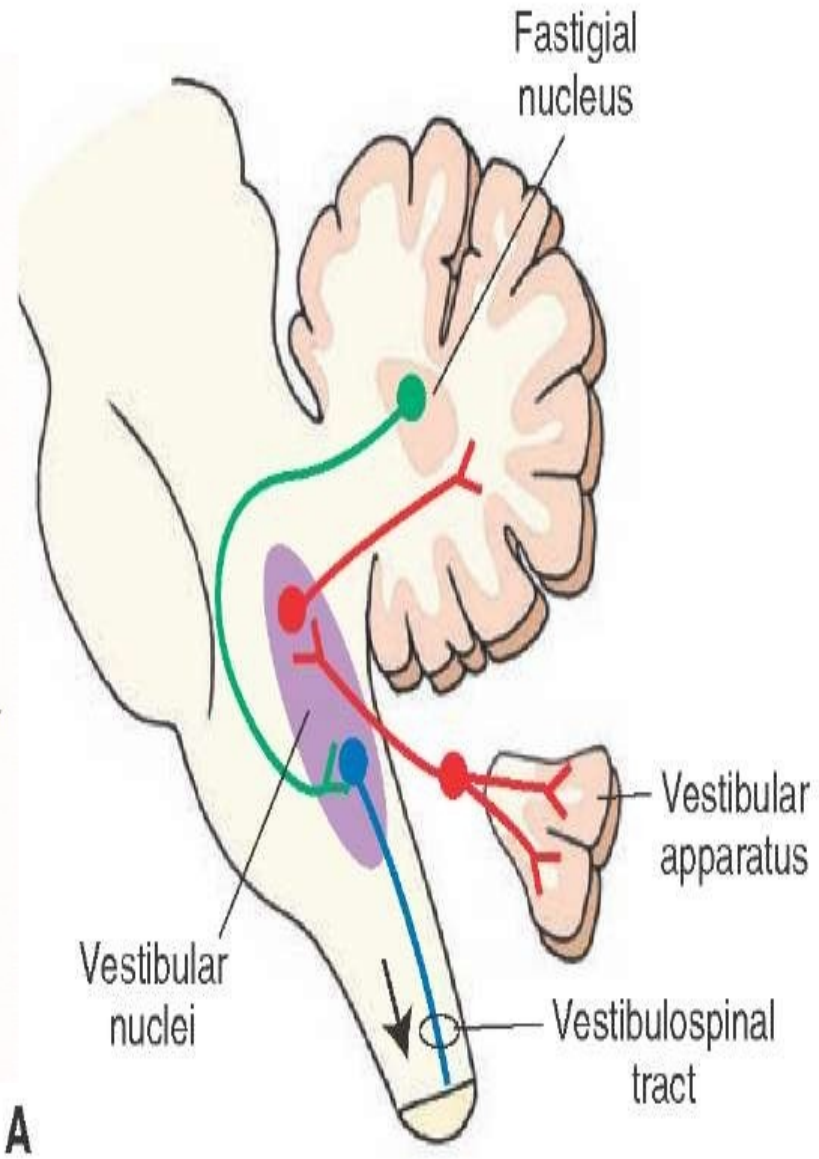
Vestibulo-cerebellum afferents

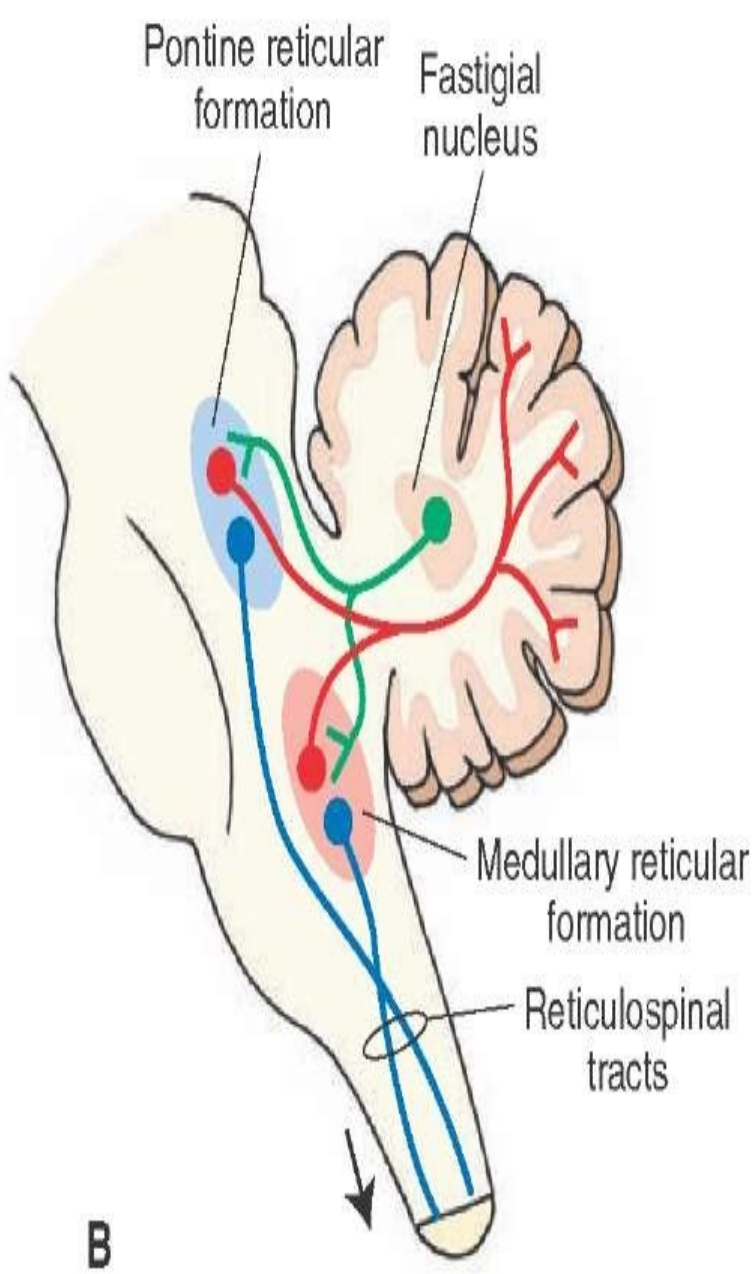
Tract	Origin	Signal
Tecto-cerebellar tract	**Tectum (superior and inferior colliculi)**	**Visual , auditory**
Vestibulo-cerebellar tract	**Vestibular nuclei in medulla or vestibular**	**Body posture, equilibrium**
Dorsal spino-cerebellar tract (Afference copy)	**Muscles (muscle spindle)**	**Propioception**
cuneo-cerebellar	**gracile, cuneate**	

Vestibulo-cerebellum efferents

Fastigial nucleus	origin
▪ **Reticular formation** ▪ **Vestibular nuclei in medulla**	target
▪ **Reticulospinal and vestibulospinal tracts** **Control axial and proximal muscles tone to maintain balance and equilibrium** ▪ **from vestibular nucleus to medial longitudinal bundle to external occular muscles** **Co-ordinate eye and head movements to maintain clear vision.**	functio n







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Vestibulo-cerebellum Functions

- 1- Maintain **equilibrium, c**ontrol balance between agonist and antagonist muscles during **rapid change in body position.**
- **2- Control eye movements:** Saccades and Pursuit movements and **co-ordinate eye and head movements**
- ***Lesion:*** **Trunkal ataxia and Nystagmus**

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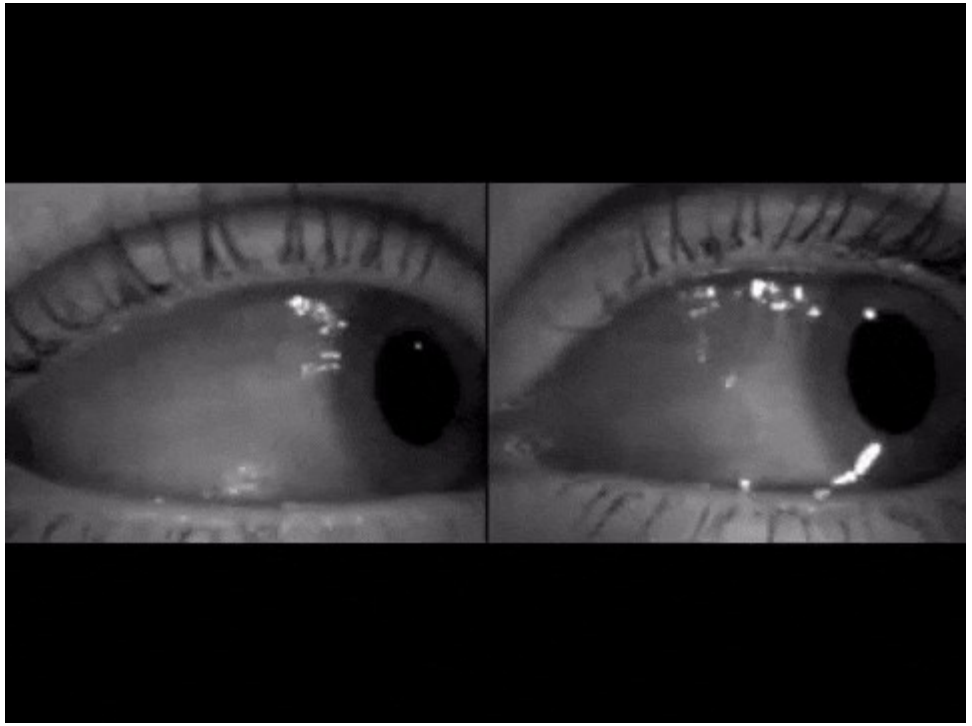

nystagmus

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Put True or false

- Vestibulocerebellum main function is planning F

Regulation of body posture, equilibrium

- Vestibulocerebllum does not depend on visual signals

Connected to tectum (visual signals)+ proprioceptors+ vestibular system

- Vestibulocerebellum is not connected with brain stem F

Send efferents through peduncles to reticular formation and vestibular nucleus

- Vestibulocerebellum send its output through fastigial nucleus F

T

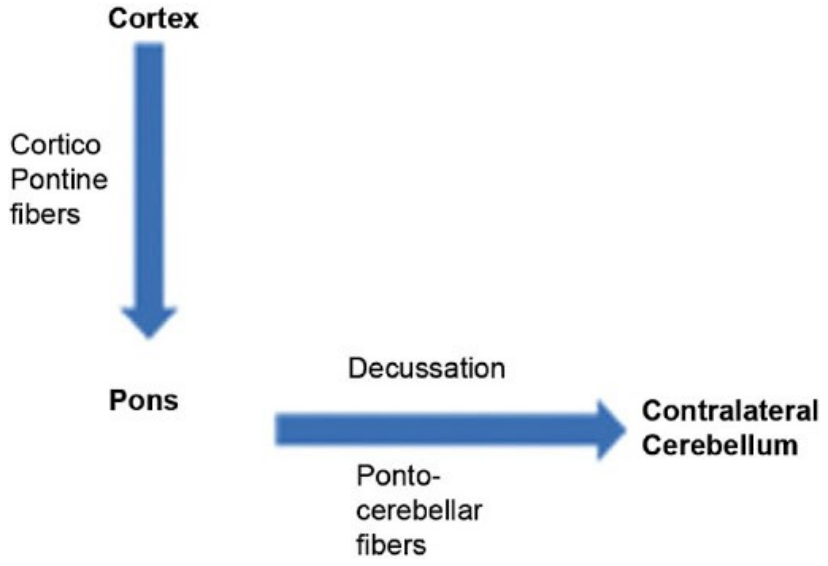
Spino-cerebellum functions

Coordinate the ongoing movement

- servo-compartor function
- Damping function
- ballistic movement

Spino-cerebellum afferents

Tract	Origin	Signal
Cortico-ponto-cerebellar pathway	**Motor cortex, somatosensory, association areas**	Intended cortical motor plan



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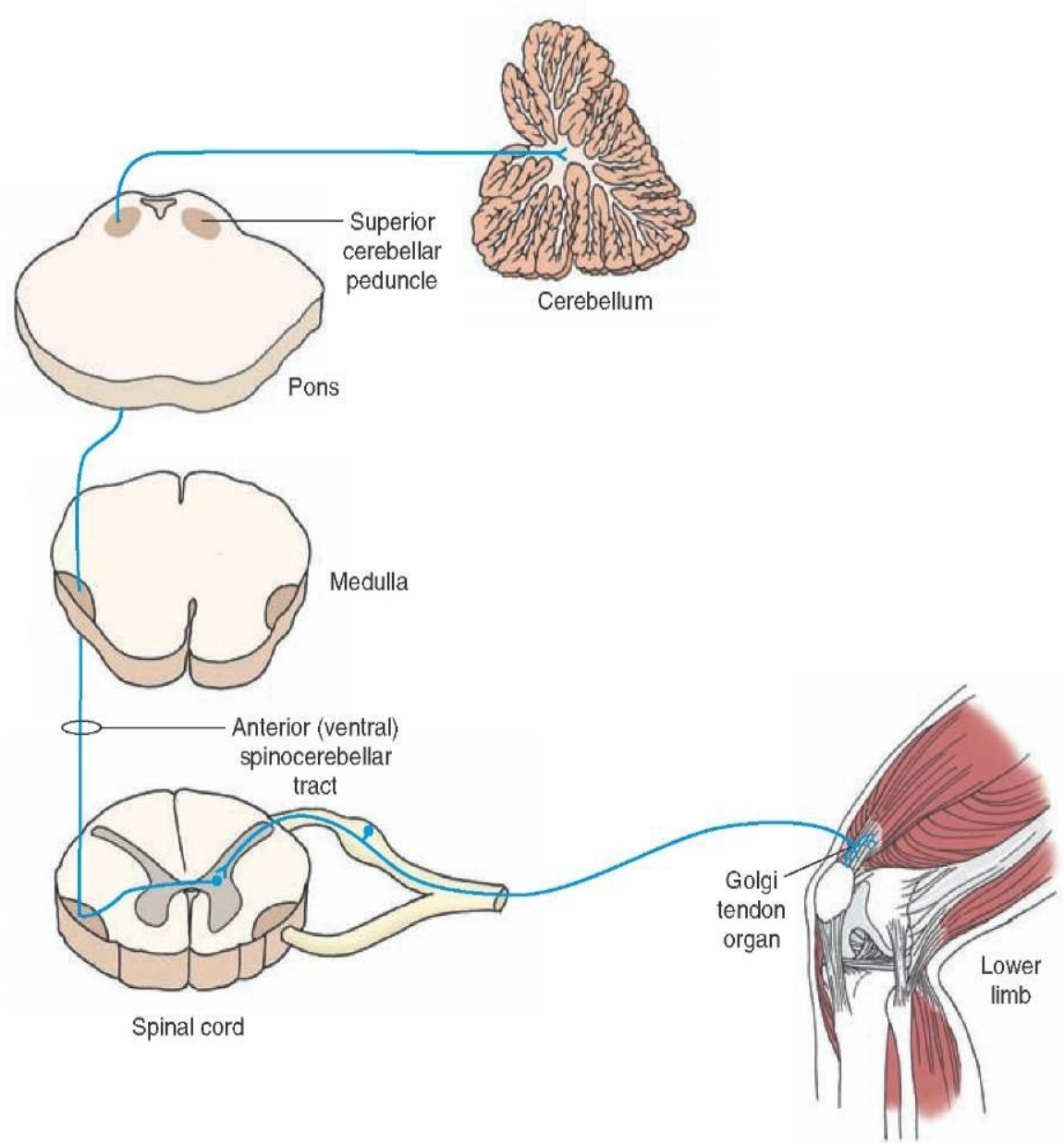
Spino-cerebellum afferents

Tract	Origin	Signal
Ventral spino-cerebellar tract (efference copy)	**Motor signals that reach anterior horn cells from cortico-spinal**	
Dorsal spino-cerebellar tract (Afference copy)	**Muscles (muscle spindle)**	**Propioception**
cuneo-cerebellar	**gracile, cuneate**	
Reticulo-cerebellar tract	**Reticular formation (receive signals from cortex + spinal cord}**	**Muscle tone, movements**

- **Spino-cerebellar tract**



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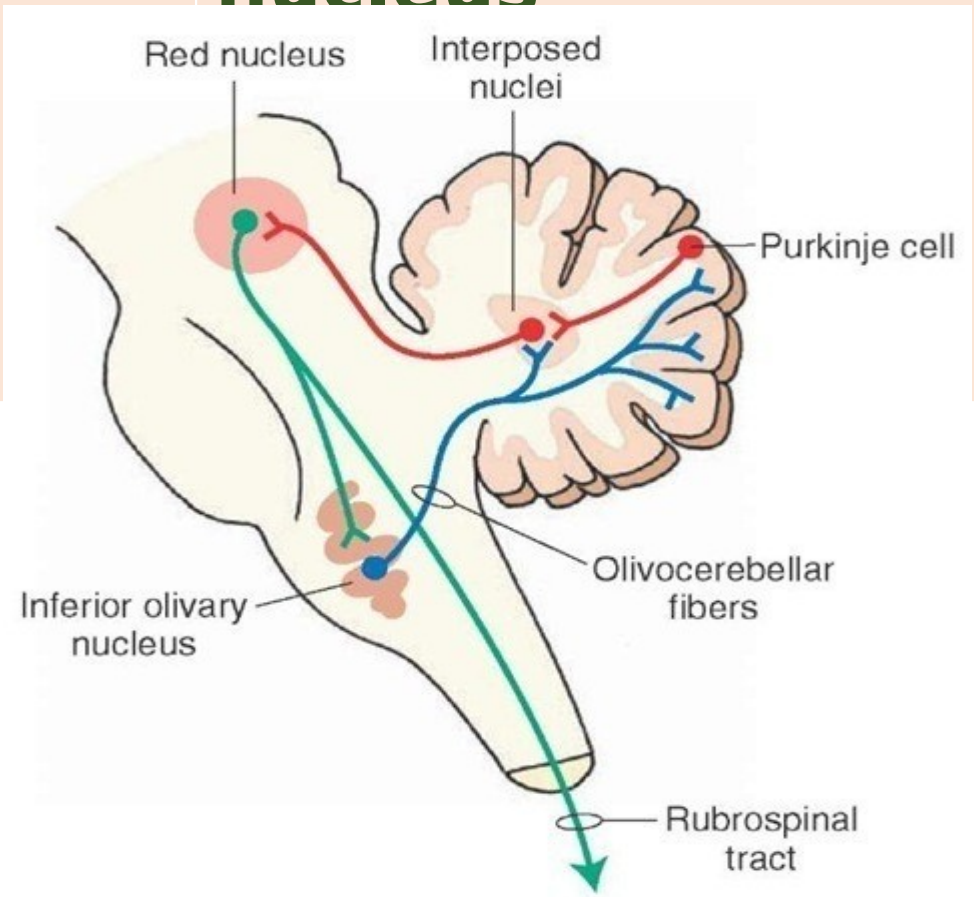
Spino-cerebellum afferents

Tract	Origin	Signal
Olivo-cerebellar tract (Climbing fibers)	**Inferior olivary nucleus**	**Comparative signals: between motor cortex, basal ganglia and spinal cord**



How can the spinocerebellum do the servo-comparator function?

- It receives the **intended cortical motor plan** and **proprioceptive** signals to know the **actual** movements

Spino-cerebellum efferents

Nucleus interpositus.	origin
▪ **Red nucleus** ▪ **Thalamus** ▪ **Reticular formation and vestibular nucleus**	target
▪ **Rubrospinal tract** ▪ **Thalamocortical tract:** then corticospinal tract **To control muscle contraction** ▪ **Reticulospinal and vestibulospinal tracts** **Control muscles tone**	functio n

spino-cerebellum Functions

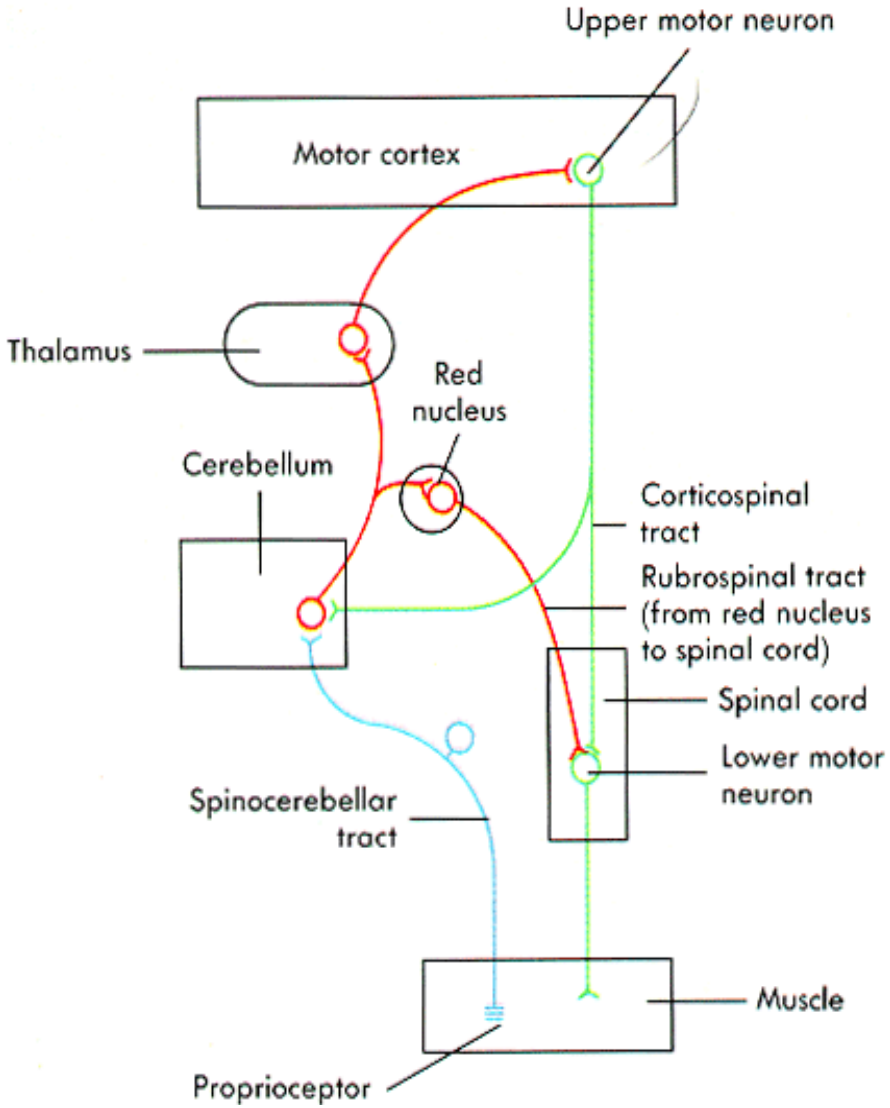
A - Servo-comparator function:

- **A-Compare:**

Signals from the motor cortex that carry the intended motor plan with actual **muscle performance during the movement (Proprioceptive feedback signals)**

B - Detect error

C- Send corrective signals from the interpositus nucleus through red nucleus and thalamus



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Corrective signals

compare

Detect error

Compare
Detect error
Corrective signals

spino-cerebellum Functions

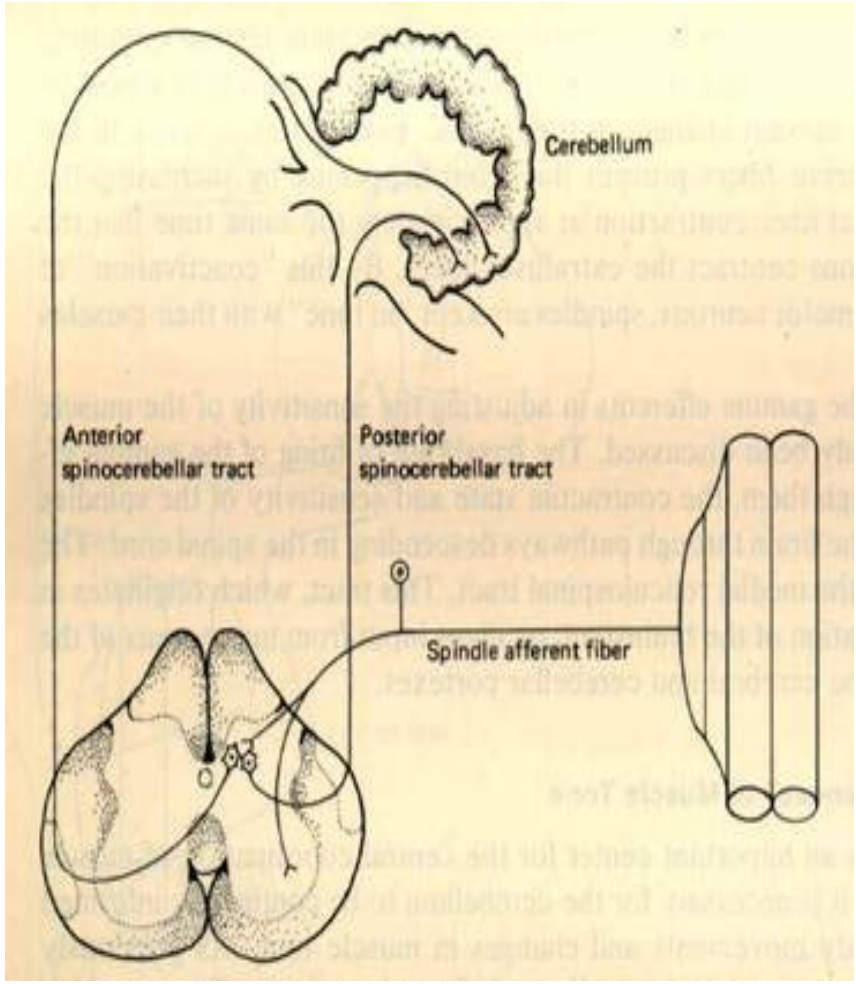
B - Damping function:

- It is the ability of the cerebellum to end movement suddenly (precisely) at the intended point, without any jerkiness or oscillations
- Cut off extra impulses
- Perform smooth accurate movements
- **Almost all movements of the body are *pendular* (due to momentum), so they have a tendency to overshoot.**

B - Damping function:

Mechanism:

increasing the stretch reflex sensitivity in the antagonistic muscle during movements. {cerebellar stretch reflex}



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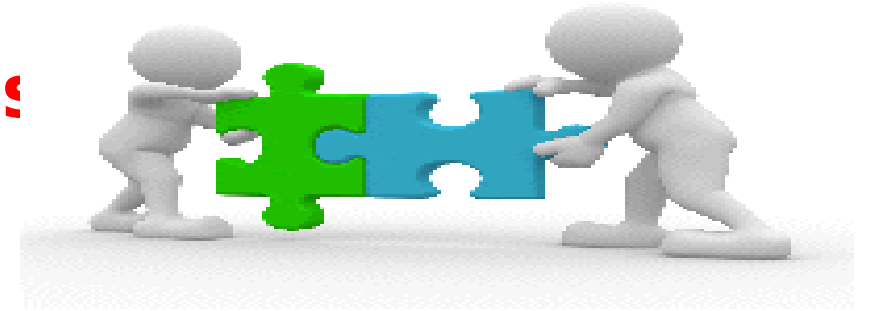
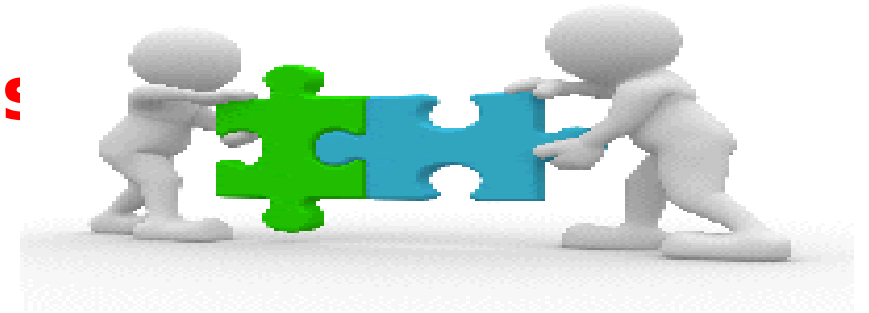
Match each statement with the right ans



1. Vestibulocerebellum
2. Damping function
3. Rubrospinal tract
4. Reticulospinal tract

A. Servo-comparator corrective signals
B. Carry conscious proprioceptive signals
C. Eye movement control
D. Cerebellar stretch reflex
E. Help in servo-compartor function
F. Help cerebellum in maintain balance

Match each statement with the right ans

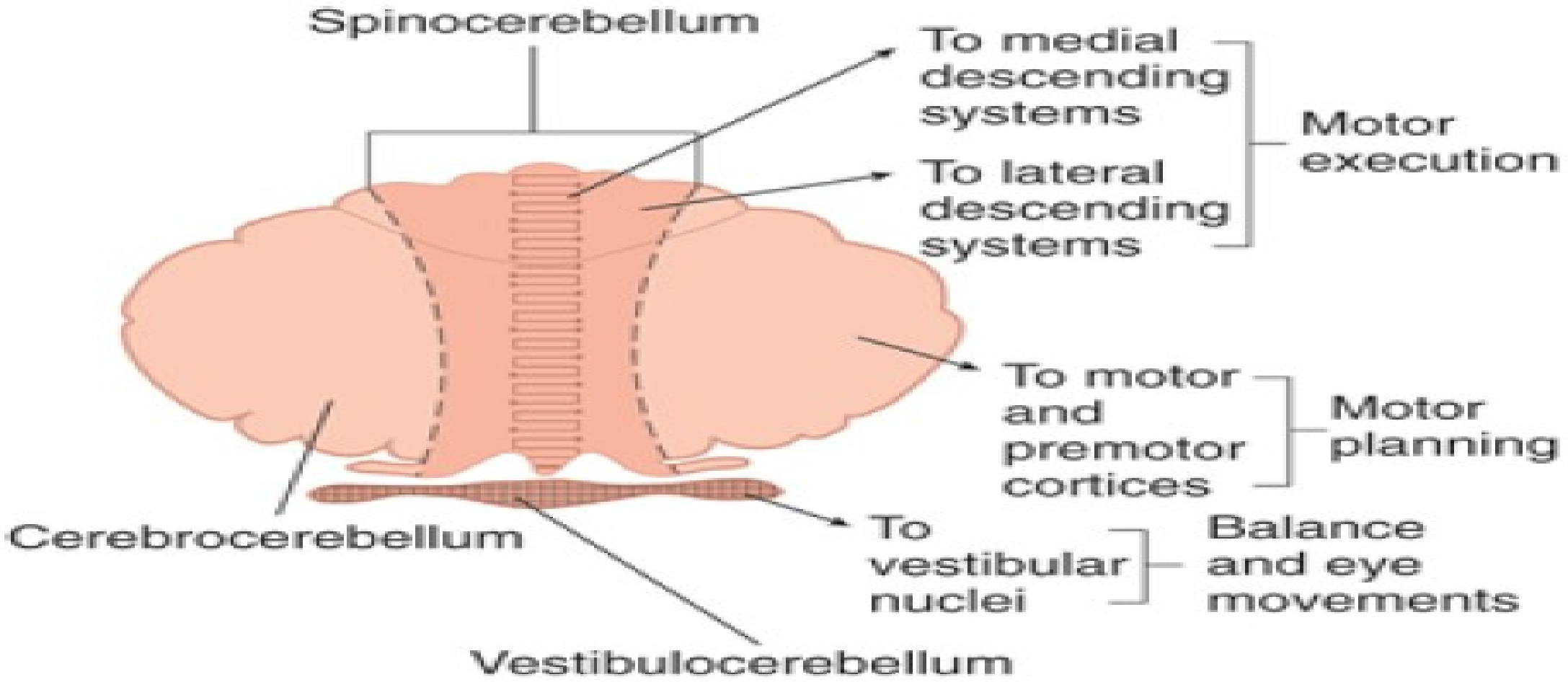


1. Vestibulocerebellum
2. Damping function
3. Rubrospinal tract
4. Reticulospinal tract
5. Spinocerebellar tract

A. Servo-comparator corrective signals
B. Carry conscious proprioceptive signals
C. Eye movement control
D. Cerebellar stretch reflex
E. Help in servo-compartor function
F. Help cerebellum in maintain balance

1	2	3	4	5
C	D	A	F	E

Summary



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Lecture Quiz

- 1----------cerebellum, regulate eye movements, by sending efferent fibers from ---------- nucleus to the ----------
- 2. ----------is responsible for damping function depending on -----
- 3. ---------- connection to the red nucleus mediate ---------- function

Lecture Quiz

- **vestibulo**cerebellum, regulate eye movements, by sending efferent fibers from ---**fastigial--**---------- nucleus to the ---------**medial longitudinal bundle--------**

- 2. -----**spinocerebellum**----------is responsible for damping function depending on –**cerebellar stretch reflex-**--
- 3. **spinocerebellum** connection to the red nucleus mediate ---**servocomparator** function

SUGGESTED TEXTBOOKS

1. Ganong review of medical physiology, 26 th edition, chapter 12-. P-569-582
2. Gyton and Hall, 11 th edition, chapter 56, p698-707